Design of Equangular Spiral Helix Antenna

Patri Upender, P. Nageswara Rao, K. R. Anudeep Laxmikanth

Abstract—This paper presents the design of Equiangular Spiral Helix Antenna in the frequency range from 0.5-18 GHz where the helical antenna is operating over the frequency range of 0.5-2GHz and spiral antenna over the range of 2-18GHz to achieve circularly polarized radiation for the same frequency band. This Antenna gives frequency range with unrealizable during a one device. VSWR, beam width, gain is determined over the entire band of 0.5-18 GHz. Designing this antenna is critical due to compact size and broadband characteristics.

Keywords—Helix Antenna, polarization, VSWR, beam width, gain, Spiral

I. INTRODUCTION

In 1954 E.M Turner developed these spiral antennas. The spiral antenna is category of freelance antenna below angular construct. Photo etching process is used for fabrication of spiral antenna on copper clad structure. Circularly polarized waves in bidirectional beam will be generated by spiral antenna perpendicular to the plane. Frequency band of radiation is limited by the physical dimension of spiral [1]. To get unifacial beam, the spiral is built at the open end of a closed back silver cavity, once within the region of λ /4 deep pre-directs this 1/2 the energy constructively to for one beam. However the energy among the cavity is absorbed to attain a broadband radiation. The spiral radiator, being a balanced device, should be fed from a balanced line. Spiral antenna consists of three main components [2]. They are:

1) The backing cavity 2) The spiral radiator 3) The balun transformer

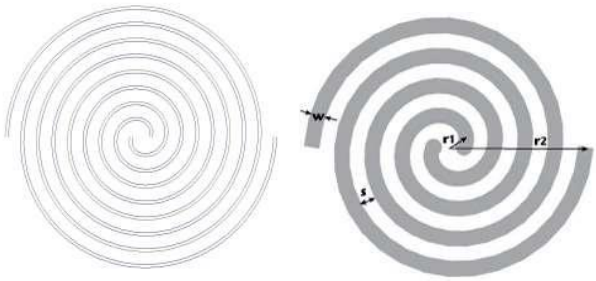

Fig.1. Archimedean spiral antenna

The equiangular spiral is one geometrical configuration whose surface can be described by angles. The equiangular spiral is described by following equation [3]

$$\rho = ke^{\phi} \qquad (1)$$

Where k is the radius of the spiral, 'k' is initial radius of the spiral, If the angle ϕ is increased by one full turn, the radius vector is increased by the factor $e^{-\pi a}$, hence each turn of the spiral is identical with every other turn except for a constant multiplier [4].

Fig. 2. Two arm equiangular spiral antenna

II. DESIGN SPECIFICATIONS

A. Design of Equiangular Spiral

The geometry of the spiral can be obtained from the equation

$R = r_0 e^{a\phi}$, r_0 is radius and a is growth rate

The smallest and largest diameters are known by the lowest frequencies and highest. To avoid end effects, the diameters must be taken 10% greater that of theoretical results.

- Lower frequency = 2 GHz
- Higher frequency = 18 GHz
- Outer diameter = 47.7 mm
- Actual diameter taken = 63mm
- Inner diameter = 5.3mm

B Balun Design

Different types of written circuit's baluns square measure on the market for connecting a 2 arm spiral antenna. Tchebychev transformation with printed circuit balun is optimum [6]. To design printed circuit broad band balun a computer program is developed. Balun consists of center conductor and ground plane, which are printed on either side of substrate as shown figure 3 [7].

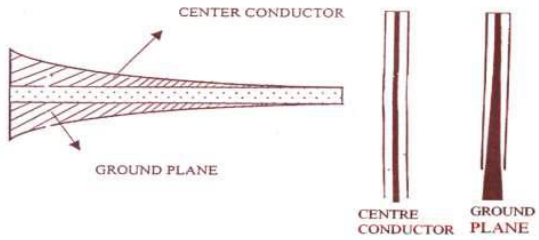

Fig. 3. Balun showing ground plane and centre conductor

Revised Manuscript Received on December 22, 2018.

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C. Cavity Design

It was designed to suit the spiral card. The measurements square having specified the aspect of the cavity same to the biggest sq. aspect of the spiral. Antenna gain is going to be most once the depth of the cavity is λ/4. In fact, this cannot be attained over the full band of 0.5-18 GHz. Hence honeycomb absorber is used to load cavity to avoid interference of the reflected signal from the bottom of the cavity [8].

Depth of the cavity = λ/4 at lower frequency.

D. Spiral antenna assembly

This antenna is soldered using the feed points of the spiral [9]. Using naked eye feed connection cannot be achieved so it is very critical [10]. Using the microscope this was done. The balun is loaded with absorbent material and also spacer discs.

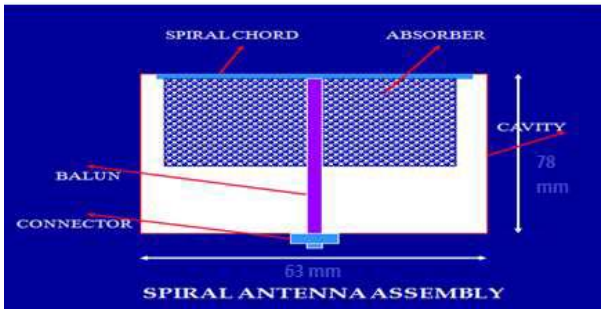
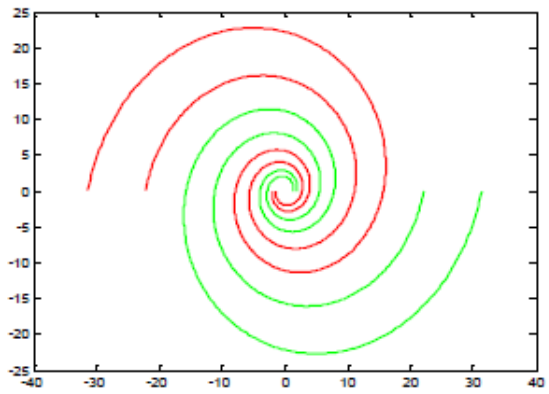


Fig. 4. Assembly of Spiral Antenna

A MATLAB program is developed for design of spiral circuit. The above data is given as input to the program developed. Spiral co-ordinates are obtained from the developed program which will be helpful in auto CAD design.



Diameter in nm in both axis

Fig. 5. Design of spiral antenna using Matlab.

The design specifications of helix are

Pitch angle = 15º, Number of arms = 2, Arm width = 9mm, Spacing = 18mm, Height = 70mm, Diameter = 63mm, Arm length = 270mm.

The design of spiral chord and balun are done using a computer program generated in MATLAB software. With the above specifications we designed a helical antenna using HFSS software and results are checked after simulation. After found the results are good enough we made a AUTOCAD drawing to sent it for fabrication.

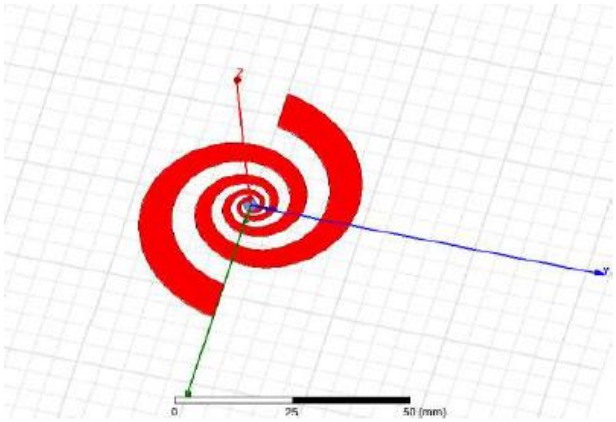


Fig. 6. Design of spiral antenna using HFSS

III. SIMULATUION RESULTS

Figure 7 gives the radiation pattern of spiral helix antenna which at 2, 6, 8, 14 and 18GHz. From the figure, it has been observed that the beam width of 59.85, 50.67, 90.07, 95.57 and 95.64 is obtained for an antenna is and axial ratio obtained is 0 for 2, 6, 8 GHz and 0.1, 0.2 for 14 and 18 GHz.

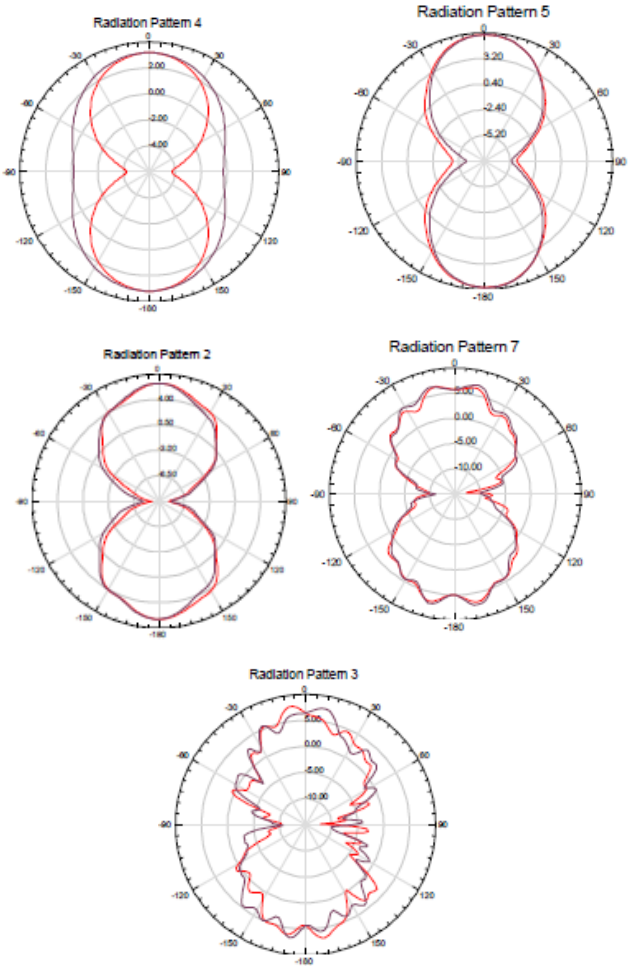


Fig. 7. Radiation pattern of spiral at 2, 6, 8, 14 and 18GHz

The antenna is measured over the frequency range of 0.5-18 GHZ. The maximum VSWR is to be 2.78 at 2 GHZ and <3.33 at other frequencies

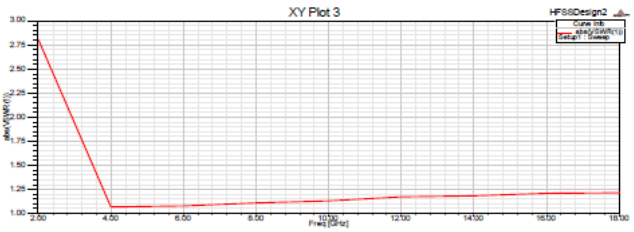


Fig. 8. VSWR Plot for spiral antenna for 0.5-18 GHZ

Using HFSS simulation of Helical antenna is as shown

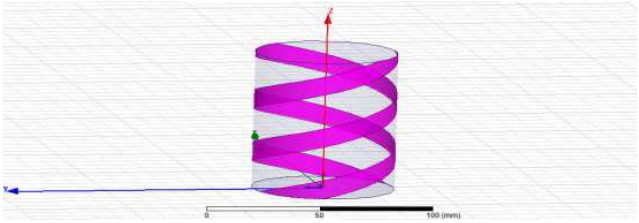


Fig. 9. Design of helical antenna using HFSS

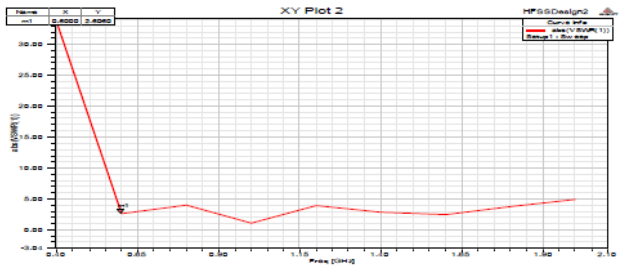


Fig. 10. VSWR plot helical antenna

Figure 11 shows the design of Helix Spiral antenna using HFSS.

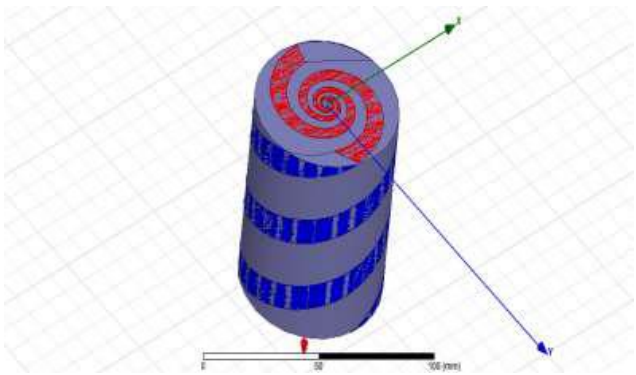


Fig.11. Design of helix spiral antenna using HFSS

IV. FABRICATION RESULTS

The design parameters determine the whole dimensions of the spiral antenna. Coordinates are obtained using the software programs developed in MATLAB. The fabrication is done by photolithographic process. Spiral antenna characteristics greatly depend on the type of material used as dielectric substrate. Thin substrates with higher dielectric constants are desirable for microwave circuitry. Hence copper clad substrate is used. For fabrication of the antenna it involves in design, master drawing, artwork layout, photo reduction, positive development, laminate cleaning, resist application, resist exposure, resist development, inspection, etching, bonding and finishing. \

Fig. 12. Practical helix spiral and spiral antenna

Figure 12 shows the helix spiral and spiral antenna fabricated using Photolithographic Process**. F**igure 13 shows radiation pattern of spiral helix antenna at 0.5, 1, 2, 6, 10, 14, 18 GHz

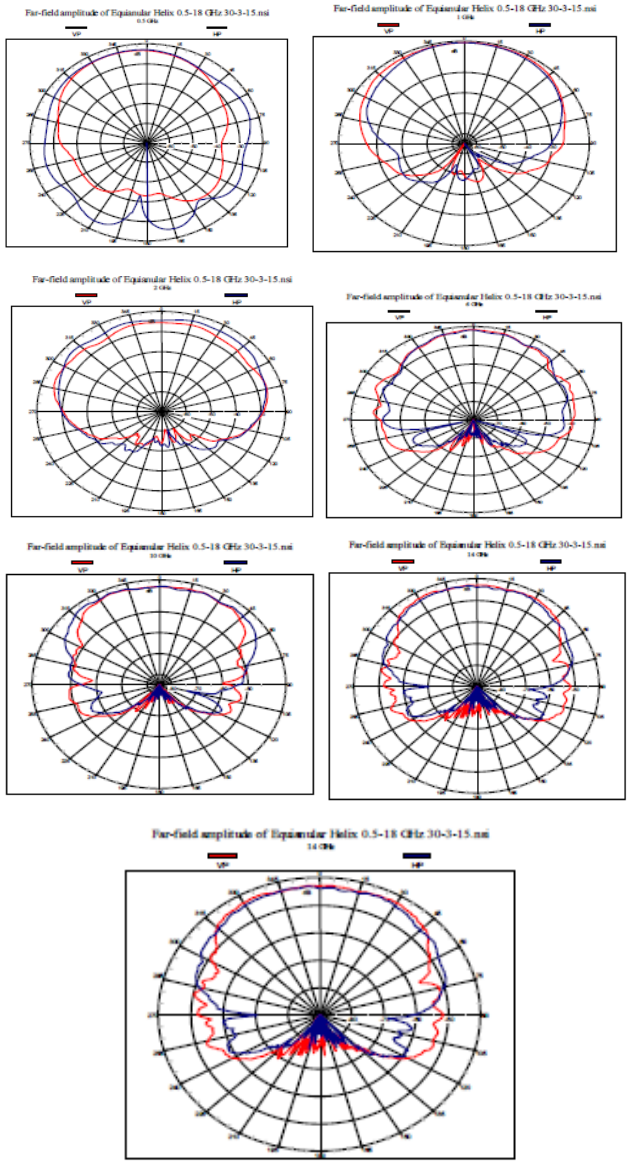


Fig. 13. Radiation pattern of spiral helix antennas at 0.5, 1, 2, 6, 10, 14, 18 GHz

Table 1.Comparision of Simulated, Realized and Specified specifications

Specifications	Specified	Simulated	Realized
Frequency	0.5-18GHz	0.5-18GHz	0.5-18GHz
VSWR	<3.5	<3.5	<2.5
Beam width	50 (min), 75(nom), 110(max)	40 (min), 80(nom), 100(max)	60 (min), 75(nom), 110(max)
Polarization	Circular	Circular	Circular
Gain	-21dB at 0.5GHz	-21dB at 0.5GHz	-18dB at 0.5GHz
Axial ratio	2dB	1.5dB	2dB

V. CONCLSUION

Equiangular spiral Helix Antenna with frequency band between 0.5 - 18GHz is designed. Circular polarization is achieved over a wide bandwidth. VSWR of 2:1(max) in the band of 0.5-18 GHz is achieved and symmetric patterns are with beam width varying from 61º to 110º, the axial ratio is obtained as 2dB. Spiral helix antenna is designed by generating computer programs and different software's. Theoretical calculations and design methodology under the frequency of is presented.

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